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(54) Apparatus and processes for the mass production of photovoltaic modules

(57) An apparatus and processes for large scale in-line manufacturing of CdTe photovoltaic modules in which all steps, including rapid substrate heating, deposition of CdS, deposition of CdTe, CdCl₂ treatment, and ohmic contact formation, are performed within a single vacuum boundary at modest vacuum pressures. A p+ ohmic contact region is formed by subliming a metal salt onto the CdTe layer. A back electrode is formed by way of a low cost spray process, and module scribing is per-

formed by means of abrasive blasting or mechanical brushing through a mask. The vacuum process apparatus facilitates selective heating of substrates and films, exposure of substrates and films to vapor with minimal vapor leakage, deposition of thin films onto a substrate, and stripping thin films from a substrate. A substrate transport apparatus permits the movement of substrates into and out of vacuum during the thin film deposition processes, while preventing the collection of coatings on the substrate transport apparatus itself.

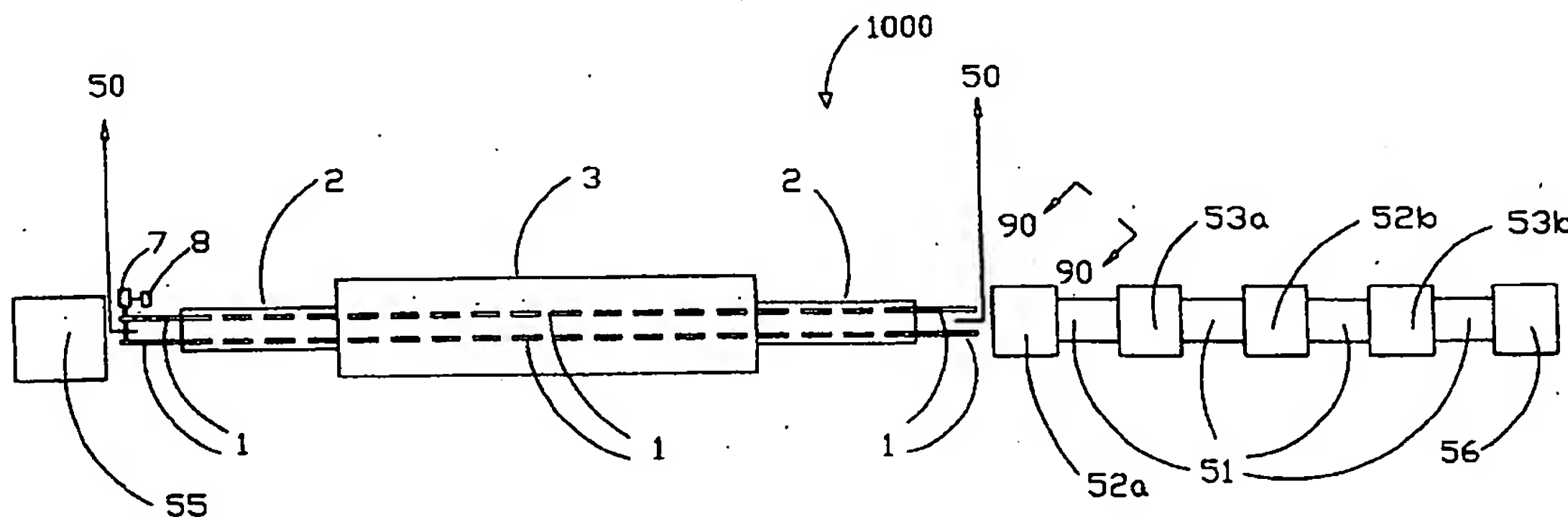


Fig. 1



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EUROPEAN SEARCH REPORT

Application Number
EP 01 30 4749

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	BONNET D: "Manufacturing of CSS CdTe solar cells" THIN SOLID FILMS, ELSEVIER-SEQUOIA S.A. LAUSANNE, CH, vol. 361-362, no. 1, February 2000 (2000-02), pages 547-552, XP004187535 ISSN: 0040-6090 * the whole document *	1-6,10, 11	H01L31/18 H01L31/0224 H01L31/072
X	MCCANDLESS B E ET AL: "A TREATMENT TO ALLOW CONTACTING CDTE WITH DIFFERENT CONDUCTORS" WORLD CONFERENCE ON PHOTOVOLTAIC ENERGY. WAIKOLOA, DEC. 5 - 9, 1994, NEW YORK, IEEE, US, vol. VOL. 1 CONF. 1, 5 December 1994 (1994-12-05), pages 107-110, XP000681264 * page 107 *	1,2,6,11	
A	ZHOU T X ET AL: "VAPOR CHLORIDE TREATMENT OF POLYCRYSTALLINE CDTE/CDS FILMS" WORLD CONFERENCE ON PHOTOVOLTAIC ENERGY. WAIKOLOA, DEC. 5 - 9, 1994, NEW YORK, IEEE, US, vol. VOL. 1 CONF. 1, 5 December 1994 (1994-12-05), pages 103-106, XP000681263 * page 103 - page 104 *	1-4	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01L
A	US 4 798 660 A (ERMER ET AL) 17 January 1989 (1989-01-17) * column 3, line 24 - line 52; figure 2 *	1	
-/--			
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 20 April 2005	Examiner Bakker, J
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application I : document cited for other reasons</p> <p>& : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03.92 (P04C01)



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Application Number
EP 01 30 4749

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 209 (E-421), 22 July 1986 (1986-07-22) -& JP 61 049483 A (MATSUSHITA ELECTRIC IND CO LTD), 11 March 1986 (1986-03-11) * abstract *	1	
A	MCCANDLESS B E ET AL: "RECRYSTALLIZATION AND SULFUR DIFFUSION IN CDCL ₂ -TREATED CDTE/CDS THIN FILMS" PROGRESS IN PHOTOVOLTAICS. RESEARCH AND APPLICATIONS, JOHN WILEY AND SONS, CHICHESTER, GB, vol. 5, no. 4, July 1997 (1997-07), pages 249-260, XP000691512 ISSN: 1062-7995 * page 249 *	1	
A	GB 2 084 197 A (UNIVERSITY OF DELAWARE) 7 April 1982 (1982-04-07) * page 1; figure 1 *	1	
<p>The present search report has been drawn up for all claims</p>			<p>TECHNICAL FIELDS SEARCHED (Int.Cl.7)</p>
Place of search		Date of completion of the search	Examiner
The Hague		20 April 2005	Bakker, J
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date O : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-6,10,11



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**LACK OF UNITY OF INVENTION
SHEET B**

Application Number
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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-6,10,11

Method of heating a substrate, depositing and
halogen-substance treating semiconductor layers and ohmic
contact formation in a single vacuum chamber

2. claim: 7

Spraying method of conductive graphite and metal

3. claim: 8

Transportation apparatus having metal belts in a vacuum
chamber

4. claim: 9

Transportation and processing apparatus having heated
pockets in a vacuum chamber

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 01 30 4749

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-04-2005

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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JP 61049483	A	11-03-1986	NONE	
GB 2084197	A	07-04-1982	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82